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ABSTRACT

This publication focuses on computer integrated manufacturing (CIM) programs at several higher education institutions which teach the use of computing in manufacturing. The document describes programs at the following institutions: University of Alabama (where researchers are investigating CIM techniques with a key focus on transferring their research to CIM packages easily implemented by small businesses); the University of Cincinnati's Center for Computer Integrating Manufacturing (where an outreach arm introduces manufacturers to CIM techniques, an educational arm offers undergraduate courses and employee retraining programs, and the research arm works to integrate the manufacturing process); Fox Valley Technical College (where affiliation with local businesses and responsiveness to the requirements of regional manufacturers has made it a leading CIM institution); University of Missouri-Rolla (which has constructed a CIM Center where undergraduates in a manufacturing technology program and senior/graduate-level students in an interdisciplinary course design and make products); Pennsylvania College of Technology and its 71 career-oriented programs (which provide hands-on education to more than 4,000 students); University of Southwestern Louisiana (which has joined with industry to revitalize Louisiana industry through technical innovation, procurement assistance, training and research facilities, and a new CIM center for the apparel industry. (JB)

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Computer Integrated Manufacturing Programs in Higher Education

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Contents

University of Alabama 4
College of Engineering
Moves CIM into the Workplace

University of Cincinnati 7
CIM Center Reaches Out
to Undergraduates and Area Industry

Fox Valley Technical College 11
Technology is Transferred to America's
Manufacturing Heartland

University of Missouri-Rolla 15
Fast Track to Graduate and Undergraduate
Manufacturing Curricula

The Pennsylvania College 19
of Technology
CIM Emerges as a Primary
Educational Focus at PCT

University of Southwestern 23
Louisiana
Partnerships with Industry
Foster Strong CIM Initiative

CIM: Computer Technology Addressing the Complete Business and Manufacturing Cycle

Manufacturing today is being challenged from all corners of the globe. National boundaries are no longer an effective defense to products offering lower cost and higher quality. To remain competitive, manufacturers must reduce development time, improve quality, and increase efficiency in the entire business cycle.

Higher education has recognized this challenge and is responding by offering programs in computer integrated manufacturing (CIM), the use of computing in manufacturing—from the identification of customer requirements to distribution of the finished product.

CIM traces its heritage to the early 1970s, when computers were first used in drafting. Known as computer-aided design (CAD), it spread from the drafting room to the manufacturing floor in the form of punched paper tape used to computer-control milling machines. Manufacturing recognized the significance of what was happening and over a period of time developed the beginnings of computer-aided manufacturing (CAM). By the late 1970s, CAD/CAM was a reality in industry, and IBM entered the marketplace.

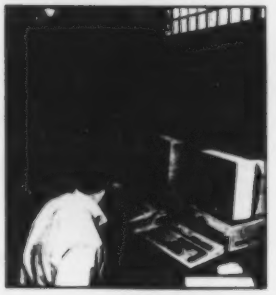
It wasn't until 1982, however, that IBM's Erich Bloch, currently director of the National Science Foundation, recognized that manufacturing needed better educated people, trained in computer techniques. While a number of two-year technical schools offered academic programs in manufacturing, only a handful of four-year schools offered manufacturing degrees. Most of manufacturing management had arrived there through the time-honored method of moving up through the ranks, and lacked the formal education necessary to take full advantage of this new, increasingly computerized environment.

Later that same year, Bloch formed an IBM task force that engaged in discussions with higher education and, by September, IBM announced a major CIM initiative. In the summer of 1983, IBM followed up with an announcement of major grants to 22 institutions for CIM academic programs totaling about $50 million.

IBM continued to encourage CIM through a variety of programs and, in December 1988, announced the "CIM in Higher Education Alliance." The alliance, which currently lists over 50 member schools, provides a forum for educators to exchange ideas and technologies in the pursuit of enhancing CIM opportunities in both education and industry.

Industry experts estimate that perhaps as much as 90 percent of United States manufacturing firms have yet to implement CIM in their operations. Leading universities and colleges are mounting a two-pronged attack designed to change this by educating enrolled graduate and undergraduate students in CIM technology while also convincing manufacturers of the advantages in retraining their current employees in CIM.

This publication focuses on CIM programs at several leading institutions and their efforts to integrate CIM into the curricula. While the schools that are highlighted here have enjoyed remarkable successes, they may be considered as typical of the CIM story in higher education.



University of Alabama

College of Engineering
Moves CIM into the Workplace

Researchers within the University of Alabama's College of Engineering are investigating CIM techniques for a wide range of applications—from manufacturing dental crowns and designing expert systems, to more efficiently casting metals. A key focus of their efforts is transferring their research—presently conducted on IBM mainframe computers—to CIM packages easily implemented by small businesses using IBM advanced-function workstations.

Dennis Webster, professor and head of the industrial engineering department, is examining comprehensive applications using CIM concepts. The department's educational program, according to Webster, covers both the technical and non-technical aspects of manufacturing.

"Our main thrust in industrial engineering is taking a broader, more generic look at the entire manufacturing process," says Webster. "We are developing software to integrate other business aspects of manufacturing. That is something typically left out in many CIM approaches."

By demonstrating CIM operations to local businesses and manufacturers, Webster hopes to expand the narrow constraints into which CIM is sometimes cast. Even where CIM operates on shop floors, he says, programs developed are frequently constrained by narrow "in-house" databases—a constraint that makes replicating the process in similar plants difficult.

"Researchers need to develop CIM packages that are more standardized, so they can be used for a whole range of applications beyond a traditional orientation of producing discrete products," continues Webster. "There is no reason why CIM concepts can't expand beyond manufacturing to service industries, like banking and fast-food outlets, that offer distinct products."

Dennis Webster, professor and head of the University of Alabama's industrial engineering department, is guiding the development of software that integrates business aspects of manufacturing often left out of CIM approaches.

CIM In the Dentist's Office

Already, within the confines of the College of Engineering's robotics and computer graphics laboratory, novel CIM applications are in full development. Reggie Caudill, a professor of mechanical engineering, is applying his expertise in CIM technology and software to 50-year-old dental procedures. Instead of several stressful visits to the dentist, Caudill anticipates patients may have crowns replaced with more accuracy and comfort in a single visit.

CIM concepts being developed at Alabama will help dentists design and produce crowns faster while the State's foundry industry could benefit from new metal casting techniques.

Reggie Caudill, professor of mechanical engineering, is transferring CIM techniques to dentistry, speeding up and automating the design and production of crowns. Specifications from a CAD workstation are sent to a four-axis milling machine.

Working with Earl Hydrick, a Tuscaloosa dentist, Caudill is applying CIM concepts to data acquisition and the actual manufacture of crowns. Caudill has integrated three off-the-shelf technologies—optical imaging, computer-aided design (CAD), and biocompatible materials—into a workable system.

"It is just like designing a manufacturing process where all facets of production are controlled by computer," says Caudill. His primary development tool in the laboratory is an IBM 5080 graphics terminal, which controls a milling machine.

Here's how a typical CIM scenario would unfold in the dentist's office. First, the dentist uses a pencil-sized optical probe to gather data about the tooth to be crowned and the adjacent teeth. Feature-based software reduces the data to more manageable quantities for processing by a CAD workstation. Caudill's programs then automatically design the crown, determine cutting paths, and send the specifications to a four-axis milling machine, which cuts the crown.

"We divide tooth surfaces into regions that are mathematically modelled," explains Caudill. "An interactive graphics program creates color contour maps that the dentist can move and manipulate."

With the power of advanced workstations like the IBM RT® System, Caudill—who has been working on the design for several years—anticipates having working prototypes available for dentists within two to three years.

Toward an Expert System

Because many dentists work intuitively and base their decisions on previous experiences, errors, especially in unique circumstances, may plague crown recipients. In response, Caudill is also designing an expert system to quantify what the "perfect" crown would be for any situation.

"You need to assess the motion and stress on adjacent and opposite teeth when a person chews," he says. "The system would precisely calculate a tooth's load-bearing strength and design a perfectly fitted crown with little guesswork involved."

Serving a State-Wide Industry

With 85 foundries employing thousands of workers throughout the state, the metal casting industry is important to Alabama. The College of Engineering is a vital resource for this industry both as a source of engineers and technicians, and for the ongoing CIM research focused on metal-casting processes.

"Computer integration hasn't come as rapidly to the casting industry as it has for metal machining," says John Berry, professor and head of the metallurgical and materials engineering department. "Few tools like this existed before."

Under a National Science Foundation grant called CADCAST, the college is modeling various aspects of metal casting—from the cooling of the molten metal within the mold to how the finished casting will behave later in service.

Although the department is heavily involved in modeling the solidification process on both macroscopic and microscopic levels (it recorded almost $1 million worth of new research starts in 1988) Berry specializes in macroscopic-level modeling—ascertaining with computers how particular cast shapes will solidify. "Macroscopic-level modeling is critical," explains Berry, "to avoid shrinkage and unsoundness that cause parts to fail in service."

Doru Stefanescu (left), professor of metallurgical and materials engineering, John Berry (above), professor and head of the metallurgical and materials engineering department, and James Hill (right), professor and head of the department of engineering mechanics, are involved in projects to improve metal casting processes. .

Because computer modeling can simulate how castings will form before actual molds are created, it saves time and money. "That is certainly an advantage over the trial-and-error process which was common practice beforehand," he says.

Closely related to Berry's work is research performed by Doru Stefanescu, professor of metallurgical and materials engineering. Stefanescu, who is developing new software to simulate aspects of the casting process, is focusing his efforts on structure to predict grain sizes and other micro-features of castings.

Stefanescu's objective is to predict how solidification and heat transfer occurs and how grain structure in the material is affected. "The soundness and load-bearing qualities of the finished part depend on the size and type of grains formed," he says.

An Expert System for Rigging

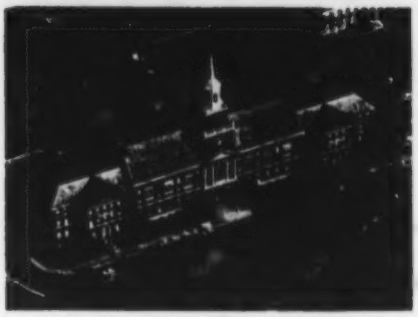
Although a casting engineer can intuitively tell where the "heavy" sections in a casting are, a computer model of a geometric shape doesn't automatically derive this data. This information, however, is critical for properly setting up the rigging—the plumbing system that moves liquid metal to the mold and provides reservoirs of material to account for shrinkage during solidification.

Traditionally, designing the rigging for castings was a practiced art which belonged to individual seasoned engineers. Unfortunately, foundries lost these valuable information resources as engineers retired or left the industry.

James Hill, professor and head of engineering mechanics, is collaborating with Berry and Stefanescu on an expert, knowledge-based system that simulates the decision-making processes engineers use to plan the rigging. A CIM program, written by Hill, extracts the geometric features and applies a weighted-averages routine that casting engineers use to make rigging decisions.

"The knowledge-based system collects and categorizes casting experiences," says Hill. "Designed to run on workstations like the IBM RT System, it will become a useful resource for many smaller foundries where it is crucial to train inexperienced casting engineers."

University of Cincinnati



CIM Center Reaches Out to Undergraduates and Area Industry

The Center for Computer Integrating Manufacturing at the University of Cincinnati is composed of four partners—the Institute for Advanced Manufacturing Sciences (IAMS), the university's College of Applied Science and College of Engineering, and IBM—operating three electronically networked laboratory sites.

Under a tripartite arrangement, IAMS is the center's outreach arm and introduces manufacturers to CIM techniques and benefits. The College of Applied Science, the educational arm, offers undergraduate courses and employee retraining programs. As the research arm, The College of Engineering works to integrate the entire manufacturing process—from initial design concepts and production to marketing and sales.

The Three-Laboratory CIM Center

In early 1989, IBM and the Institute for Advanced Manufacturing Sciences (IAMS)—a non-profit organization created in 1984 by the state of Ohio, the City of Cincinnati, and public-spirited groups to stimulate the use of high technology by industry—each contributed approximately $350,000 in hardware to establish a Center for Computer Integrated Manufacturing at the University of Cincinnati. The other two center partners are the University's College of Applied Science and the College of Engineering.

"We've always had a strong interest in computerized manufacturing techniques," says Frederick Kryman, dean of the College of Applied Science. "And IBM has a history of being a catalyst, encouraging higher education to work with industry on modern industry problems.

"We're a more structured organization than most other CIM facilities," Kryman says, "because we operate three separate labs." The College of Applied Science, the College of Engineering, and IAMS each run one of the labs. "Our first-year challenge is coordinating this new venture."

This "tripartite arrangement" is governed by a Board of Directors consisting of the dean of UC's College of Engineering, the executive director of IAMS, two IBM representatives, and Kryman. In addition

Frederick Kryman, dean of the College of Applied Science, oversees operation of a CIM laboratory that is dedicated to educational objectives.

University of Cincinnati

"We've got a dual focus at the center—the outside industrial community and our inside undergraduate community. So we'll be providing industry with training and retraining classes, and integrating that material into our normal curricula in order to develop a pool of young graduates familiar with the latest CIM technology."

DAVID WELLS, HEAD, ENGINEERING TECHNOLOGY DEPARTMENT, COLLEGE OF APPLIED SCIENCE

to the Board, there are directors of education, research, and technology. Representatives from local corporations and UC's Business College act as the CIM center's advisory group.

CIM Center Configuration

The center's CIM system is driven by an IBM 9375 minicomputer housed in the IAMS lab and connected by modem to two remote units respectively located in the College of Applied Science and the College of Engineering labs.

The IAMS lab is equipped with engineering and computer-assisted design (CAD) workstations, as well as personal computers, printer, and plotter. Also, the IBM 9375 is connected by direct cable to a work-cell controller located off-site in IAMS' factory-floor simulation area. The work-cell controller is, in turn, connected to a machine tool turning center.

The College of Engineering research lab is also equipped with a work-cell controller connected to robotic and programmable logic control (PLC) equipment as well as complementary IBM PS/2* and IBM RT System workstations. The College of Applied Science lab is the center's classroom and is equipped with 10 PS/2 and four IBM RT System workstations using CATIA* and CAEDS* software.

Each site has its own internal local area network (LAN), either an Ethernet† or IBM Token-Ring Network. CATIA and CAEDS are the primary CAD software used by the center.

IAMS: The Outreach Arm

Because its mission is to promote industrial use of computer technology, IAMS plays a key role in achieving one of the center's primary goals: To help industry from Ohio and elsewhere become more productive by adapting CIM to its own manufacturing processes.

"The whole point of IAMS is to show industry how to apply technology in the workplace and on the shop floor," says Kryman. "In particular, we aim to demonstrate to small and medium-sized concerns the benefits of integrating computers into manufacturing."

IAMS does this by going out into the field "to market the message" by hosting conferences and seminars. "These aren't training sessions," Kryman stresses. "They're 'technology transfer events' focused on orienting non-technical, general managers to what CIM is and what CIM technology can do."

IAMS also plans to enlist area companies in a team approach to develop generic demonstrations of CIM technology. "We separate manufacturing into a common *infrastructure* shared by all manufacturing, and *process*, which is unique to producing a given product," Kryman explains. "Historically, most attention has been paid to process and now we'll address the manufacturing commonalities that can become more globally competitive through CIM technology.

*CATIA is a trademark of Daussault Systems
†Ethernet is a trademark of Xerox Corp.

David Wells (left), head of the College of Applied Science's mechanical engineering technology department and the CIM center's educational director, focuses on both undergraduates and the outside industrial community. In the College of Applied Science CIM center lab (above), students, factory workers, professional engineers, and others involved in manufacturing have access to state-of-the-art hardware and software when participating in university courses and seminars.

"However, we also recognize that Cincinnati is a strong manufacturing area," Kryman continues, "and we'll keep the 'M' in manufacturing by jointly working on process-oriented projects with individual companies." Such projects would be undertaken on the understanding that IAMS would be able to use jointly developed CIM process solutions as part of its outreach and demonstration programs.

College of Applied Science: The Education Arm

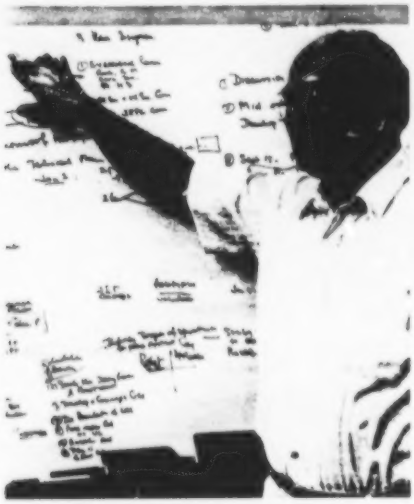
"The College of Applied Sciences has always worked closely with industry because we focus on how current engineering technology can be used to solve present-day problems," Kryman says. "For this reason, it's logical that we act as the center's education arm."

David Wells, head of College of Applied Science's mechanical engineering technology department and the center's education director, says: "We've got a dual focus at the center—the outside industrial community and our inside undergraduate community. So we'll be providing industry with training and retraining classes, and integrating that material into our normal curricula in order to develop a pool of young graduates familiar with the latest CIM technology."

The College of Applied Science faculty will offer special seminars and training in CIM techniques to factory workers, professional engineers, and others involved in manufacturing. "We'll help everyone,

"We're talking about more than plant floor robots. We're talking about grafting the business and marketing ends onto the manufacturing process itself."

ATMARAN SONI, PROFESSOR DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING



Atmaran Soni, professor in the department of mechanical and industrial engineering, says the CIM center will focus first on flexible manufacturing and flexible assembly.

from the high school graduate to Ph.D.s, as well as all types of businesses—from multinationals to small firms that can't afford extensive employee development programs," Wells says. He suspects that, by taking center courses, blue collar, production-line workers could wind up with higher paying jobs.

For undergraduates, Wells predicts another positive result. "Through the center, enrolled students will have access to state-of-the-art CIM hardware and software and this advantage will increase their job marketability. They'll be five to seven years ahead technologically."

Wells looks forward to what he considers the best sign of success. "I believe we'll soon experience a pressing need for more student workstations, as well as a demand that we expand our accessibility by offering CIM courses on- and off-site."

College of Engineering: The Research Arm

Professor Atmaran "Abe" Soni of the department of mechanical and industrial engineering serves as the center's research director. Soni, who is also an Ohio Eminent Scholar and Scott Alter Professor of Advanced Manufacturing Systems, sees research at the center advancing in expanding phases.

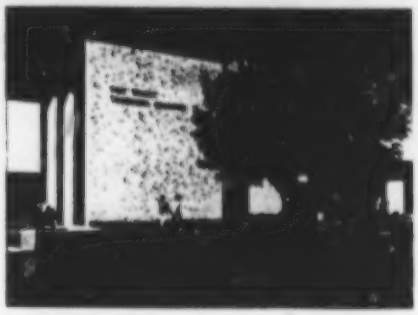
The first phase will focus on flexible manufacturing systems, integrating design, production, and manufacturing. "A number of Ohio industries are interested in developing this CIM concept to their own specific applications," Soni says, giving an example. "Ohio has the most heat-treatment plants in the U.S., but they're highly manual and thus behind overseas competitors, who have computerized production scheduling and materials handling systems."

Another closely related research area is flexible assembly. "Flexible assembly requires parts—whether made in-house or supplied by outside vendors—to be designed to facilitate assembly with minimum time and effort," he explains. "Our CAD workstations and software programs allow us to take a design concept to reality in order to prove its manufacturability."

The ultimate CIM goal, of course, is to coordinate the entire manufacturing cycle—from the earliest design ideas through to production and sales. "We're talking about more than plant floor robots," he says. "We're talking about grafting the business and marketing ends onto the manufacturing process itself."

According to Soni, full-scale CIM would enable a secretary to take an order by telephone and key that data into a computer that would control the production process—by checking parts inventories and making sure the right components are assembled—and ultimately ship the finished product to the customer. "We've got to integrate manufacturing from beginning to end in order to remain internationally competitive," he stresses.

Fox Valley Technical College



Technology is Transferred to America's Manufacturing Heartland

Close affiliation between the Board of Directors at Fox Valley Technical College in Appleton, Wisconsin, and local business has been characteristic of this community-oriented technical college. Response to the requirements of regional manufacturers to automate has led to Fox Valley's commitment to become a leading CIM institution. In keeping with its motto, "We do not succeed until you do," Fox Valley, which joined the IBM CIM Alliance in 1988, is embracing CIM in most of the college's departments.

Stan Spanbauer, president of Fox Valley, is forging an alliance between the college and small business by actively developing a CIM environment. Doing so, says Spanbauer, will serve the needs of the local business community better by facilitating their transition to becoming sophisticated, internationally competitive manufacturers.

Spanbauer's approach to CIM has been institution-wide—a policy that he says makes Fox Valley's curriculum more relevant. Thirteen instructional and three non-instructional departments are involved in CIM. That positions Fox Valley to transfer comprehensive manufacturing knowledge to businesses where CIM strategies are applicable.

Stan Spanbauer (left), president of Fox Valley Technical College, is using the institution's CIM capabilities to help create an alliance with small business. Bob Keehan (above), manager, special projects-CIM, has created a guided tour and a special CIM-related gift for visitors.

"I view CIM as part of a transformation of the school that is paralleling a transformation in industry," says Spanbauer. "We focus on teamwork and a systems approach and review each step of the process just as business does."

"Our staff, the curriculum, and the hardware and software emulate a true manufacturing environment," he continues. "Our role is not only to develop the plan and give technical assistance to businesses, but also to sell the strategies to those businesses that don't realize the need to implement CIM."

Fox Valley Technical COLLEGE

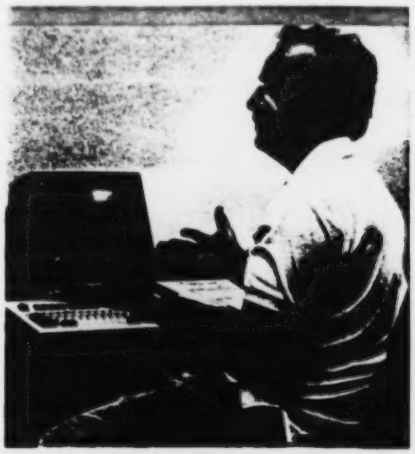
Personalized Desk Sets

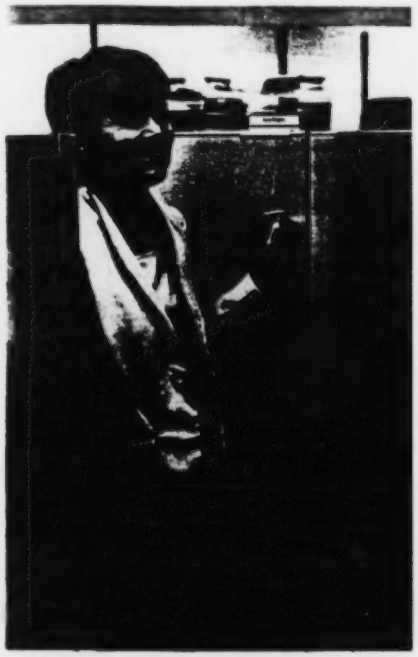
When local industrialists visit Fox Valley, they gladly hand their business cards to Bob Keehan, manager, special projects-CIM, because by the time they conclude their tour of the school's CIM sites, a personalized, engraved wooden pen-holder awaits them.

More significant than just a souvenir, the finely crafted desk ornament represents an important objective of CIM: an ability to quickly deliver customized products. "Our project is unique—the integration of CIM into Fox Valley resembles an actual business environment," says Keehan. "We incorporate the same elements that a small manufacturer does—from order entry, product design, and accounting through to manufacturing."

Fox Valley acquired an IBM AS/400™ minicomputer during the summer of 1989 as a focal point for its CIM computing—a machine they feel represents the equipment local industry can easily and successfully apply to CIM. An IBM Token-Ring Network, installed a year earlier, facilitates the flow of information between the various departments participating in the school's CIM initiative and provides access to Fox Valley's two IBM 4381 mainframes.

By summer 1989, according to Keehan's assessment, Fox Valley's implementation of CIM was nearly 50 percent complete. "We're probably in the middle . . . there is a lot of automation on campus and departments are exchanging information over the IBM Token-Ring Network. From now on we will emphasize software development and training."





Chet Jenson (above), is an instructor in the mechanical design department, which uses networked IBM PS/2 Model 80 workstations. Kaye Rogers, cost accounting instructor, prepares her students for jobs with smaller firms that will have to adopt CIM techniques to remain competitive.

How the System Works

As Fox Valley installs CIM, delivering personalized desk sets to visitors effectively simulates the flexibility of the technology and highlights the integration Fox Valley is striving to achieve.

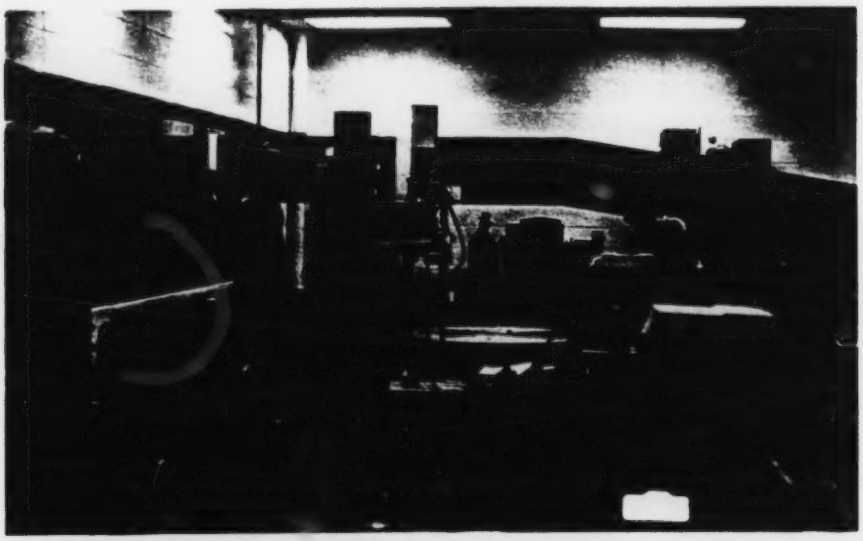
Visitors enter their order for a desk set at a "business office" where Kaye Rogers, a cost accounting instructor, provides a short overview of MAPICS. Fox Valley uses this IBM software to teach students about capacity requirement planning, forecasting, and manufacturing production scheduling in CIM applications.

"We order the black walnut wood for the desk sets from our branch campus in nearby Oshkosh, which we treat as a just-in-time supplier," explains Rogers. "Many smaller manufacturers who serve larger manufacturers are being forced into the CIM environment by the shift toward the Japanese style of just-in-time supply. We view those companies as an important part of our target market and as customers for our students."

Next stop on Keehan's tour is Fox Valley's computer-aided-drafting department and instructor Chet Jenson. An IBM PS/2 Model 80 workstation tied to the network allows visitors to modify or change any pen-holder parameters.

"We modify and customize the basic design to demonstrate how easy and quick it is to alter products before sending the information down to manufacturing," he says.

When local industrialists visit Fox Valley, they gladly hand their business cards to Bob Keehan, manager, special projects-CIM, because by the time they conclude their tour of the school's CIM sites, a personalized, engraved, wooden desk set awaits them.



Jon Stenerson (left), an instructor in the automated manufacturing technology program, oversees student assembly of flexible manufacturing cells in the brightly colored CIM lab (above).

Jensen uses a network of ten IBM PS/2 Model 60s to teach students computer-aided design. The 32 drafting tables in his lab are used less and less as students shift from manual to computer-based drafting. IBM 5080 graphics terminals provide mainframe experience on CAD programs like CATIA and CAEDS.

"Our goal is to load several packages—like MICRO CADAM*, AutoCAD†, and IBM CAD on each PS/2 workstation so students will have an opportunity to choose which software they want to use," he says.

In addition to regularly scheduled classes, Jensen teaches special evening classes in AutoCAD for students working during the day. "The demand is so great that students must register six months in advance," he says.

Designing and Operating Flexible Manufacturing Cells

In a corner of the Fox Valley campus, Jon Stenerson, an instructor in the automated manufacturing technology program, supervises students who tear down and build a flexible manufacturing cell in a 12-week period. Waving his hand at the brightly colored robots, Stenerson says these are the final components—and the smallest part—of the entire CIM network at Fox Valley. "We view CIM as a total enterprise, not just as manufacturing," he says.

It is here among the cells in the student manufacturing lab that visitors to Fox Valley can watch a carbon dioxide laser burn their names onto their desk sets. Students working in the manufacturing lab are typically at the end of a two-year program. To successfully complete the final course, called "Systems Integration," students must design, program, and build a manufacturing cell.

"They get a robot, a vision system with two sensors, and assorted pieces of hardware," explains Stenerson. "They have to assemble the hardware, write all the software, integrate hardware and software, and write a complete manual for the manufacturing cell. During the 12-week course, they are pretty busy."

In addition to preparing students for CIM environments they will encounter when they leave Fox Valley, the college is exploring new applications for automated welding with local companies.

Fox Valley leased an automatic welding machine in July 1989. Now the college's

*MICRO CADAM is a trademark of CADAM, Inc.
†AutoCAD is a trademark of Autodesk, Inc.

metal fabricating department invites local companies to send their best welders for one to two weeks of training. After the welders have learned to operate it, Fox Valley ships the pallet-mounted welding cell to their plant so they can experiment to determine the applicability, and financial feasibility, of automated welding in their manufacturing process.

This unique program allows local manufacturers to try out new technology on their shop floor with no financial risk.

From Obsolete Equipment to Industry SWAT Teams

Virg Noordyk, dean of the Technical Division at Fox Valley, recalls that it wasn't too long ago when the institution depended on donated equipment—typically obsolete—for training its students. A growing awareness of Japanese manufacturing strength, however, prompted the State of Wisconsin to provide funds for equipment purchases. Fox Valley invested in CIM hardware.

"We thought it was feasible to start developing an automated manufacturing program using a robot as a component of automation," says Noordyk. "Doing so has resulted in several industry partnerships that refined our educational objectives."

Imparting a complete understanding of CIM to students by emulating a CIM environment characteristic of industry is a primary educational thrust, says Noordyk. A secondary thrust, he explains, is developing technology transfer SWAT teams.

Virg Noordyk, dean of the Technical Division at Fox Valley, says that several industrial partnerships leading to the CIM program have refined the school's educational objectives.

"Team members are instructors well-versed in CIM concepts. The joint efforts of the team and students will help industry develop and implement a successful plan of automated manufacturing," he says. "Student involvement is important because they need to view manufacturing processes and make recommendations for incorporating CIM."

Directly adjacent to the campus is the recently completed Bordini Center, a "research park" partnership between local government agencies and business, which was designed to foster economic development and provide on-the-job training. "The entrepreneurs and start-up businesses that locate there are an extension of our educational facility," says Noordyk. "Once our initial CIM demonstration on campus is complete, there will be several years of additional work here. With the research park next door our CIM activity may evolve continuously."

University of Missouri-Rolla

CIM is Basic to Graduate and Undergraduate Engineering Curricula

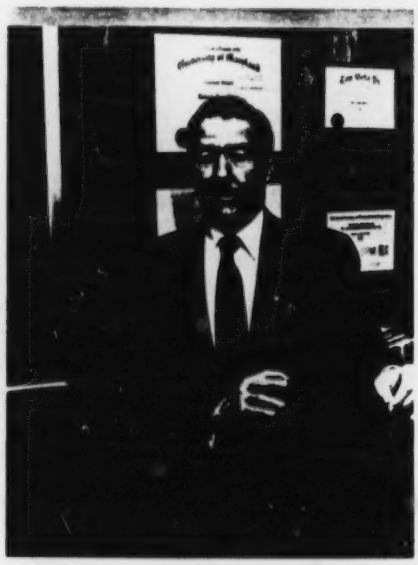
The University of Missouri-Rolla (UMR) has made a major commitment to the teaching of CIM. Aided by support from the AT&T Foundation and grants from IBM, UMR has constructed a 5,200 square-foot CIM Center in its new engineering management building. Here, undergraduates in a manufacturing technology emphasis program—and senior/graduate-level students in an interdisciplinary "capstone" CIM course—design and make products.

The UMR CIM initiative is intended to help raise U.S. competitiveness in manufacturing. UMR has also created DemMaTec—a non-profit corporation designed to transfer CIM expertise to hundreds of small and medium-sized businesses by the early 1990's.

Developing a Manufacturing Instructional Emphasis Program

One of the nation's leading sources of engineering graduates, UMR has marshalled its own and industries' resources to integrate CIM into its basic curricula. The university considers CIM vital to the future of U.S. manufacturing.

Successful implementation of CIM concepts can help restore the competitiveness of this country's manufacturing industry," notes UMR Chancellor Martin Jischke. "In focusing on engineering science and product technologies, the U.S. has slipped in the process technologies. Education can play a key role in regaining lost ground."



Martin Jischke (left), chancellor of the University of Missouri-Rolla, says the need for CIM education and research was recognized by the university in the mid-1970s. Robert L. Davis (above), dean of the School of Engineering, helped set up an instructional emphasis program on manufacturing technology and automation.

UMR first recognized the need for CIM education and research in the mid-1970s. By the early 1980s, students at all levels were using CAD/CAM techniques in a variety of courses—with full access to computer graphics, personal computers, workstations, and computing facilities. The university saw a dramatic increase in campus computing through the decade, developing a series of learning centers, extensive telecommunications capabilities, and a major IBM mainframe computer center.

"CIM was a logical next step for UMR," observes Robert L. Davis, dean of the School of Engineering and currently an IBM/ACIS Consulting Scholar. "The concept is more interdisciplinary. It helps us train technical managers, people who can look at an entire process from initial order through packaging and distribution."

In 1986, UMR established an instructional emphasis program in the areas of manufacturing technology and automation. Students of engineering management and chemical, electrical, or mechanical engineering could specialize in CIM-related technology—taking roughly 120 hours of required undergraduate courses plus 12-14 credit hours of electives ranging from "Computer-Aided Manufacturing of Polymeric Materials" to machine-vision classes and engineering management instruction with a CIM flavor. The culmination was an interdisciplinary CIM lecture/laboratory course offered at the senior/graduate level.

New State-of-the-Art CIM Center

Focal point of the CIM initiative at UMR is a 5,200-square-foot CIM Center built on the first floor of the new engineering management building. Outfitted with industry-grade production equipment, the "lab" portion of the center includes a computer-numerically-controlled (CNC) milling machine, CNC lathe, loop conveyor, six-axis servo robot, an automated storage/retrieval system, a bar-code reader, programmable controllers, packaging machines, and IBM PC AT® and PC XT™ microcomputers. All of the equipment is integrated to form a single, flexible manufacturing cell.

"The entire process is automated," says Associate Professor of Engineering Management Sema Alptekin, who is both designer and director of the facility. "Previous efforts at automated factories typically used robots as separate 'islands of automation,' with people still responsible for maintaining inventory and coordinating the process."

(L to R) Colin Benjamin and Ray Kluczny, associate professors of engineering management; Yildirim Omurtag, chairman, department of engineering management; and Sema Alptekin, associate professor of engineering management and director of the CIM lab, view a plotter output in the CIM Center classroom facility.

Built in 1987, the facility was enhanced by a grant from IBM for computer equipment, including an IBM ES/9370™ mainframe processor, an IBM 7552 industrial computer, and an IBM RT System. The IBM grant also covers additional CAD and computer-aided engineering (CAE) software as well as a multi-tasking system for the new computers.

Focal point of the CIM initiative at UMR is a 5,200-square-foot CIM Center built on the first floor of the new engineering management building.

The CIM lab—heart of UMR's new CIM Center—is outfitted with industry-grade production equipment. Computers link mechanical components to form a single flexible manufacturing cell.

Adjacent to the CIM lab is a physical-simulation laboratory used to model robotics systems—plus separate systems and testing laboratories for packaging engineering study. All told, the CIM Center and related computer labs represent roughly $1 million worth of equipment. The facilities have stimulated course development, enhanced existing courses, and fostered UMR research projects that have earned national recognition for students and faculty alike.

A newly acquired Advanced Technology Classroom (ATC) means that the engineering department can now "teach with technology" in the classroom as well as in the lab.

Capstone Interdisciplinary CIM Course

In fall 1988, the UMR engineering management department introduced "Interdisciplinary Problems in Manufacturing Automation," a team-taught course designed for seniors and graduate students who have completed the manufacturing instructional-emphasis program. Built around the use of the CIM Center, the course taps faculty expertise in a blend of lectures, lab work, and demonstrations.

The capstone course is divided into short, two-week segments. Current short courses include "Industrial Polymers and Their Processing," "Machine Vision for Manufacturing," "Programmable Logic Controllers," "Statistical Process Control," "Networks in Manufacturing, Planning, and Scheduling of the Production Process," and an integrated manufacturing laboratory.

Each class is organized into small interdisciplinary teams. Two projects are required during the semester. The first involves detailed design of a manufacturing system for a product that can be made in several different versions, usually a penlight. Each team competes by taking different approaches for the final design and manufacturing processes. The second project, primarily a lab exercise, takes students through much of the actual manufacture and assembly—resulting in a functioning system for producing the product.

Evidence of university/industry collaboration is DemMaTec, a non-profit corporation created by UMR to aid industry in adapting and implementing new manufacturing technologies.

Notes Yildirim Omurtag, chairman of the engineering management department, "The capstone CIM course complements computer-aided management concepts already introduced and gives students the chance to work with industry-grade equipment and apply theoretical concepts. Students from different disciplines learn how to program robots, design parts with a CAD package, write programs for the CNC milling machine and lathe, program a system to pick parts by priorities, practice cost estimating, and provide shop floor control—all using a CIM software package."

Positive Reaction and Industry Outreach

Reaction to the UMR CIM initiative has been highly positive. A vibrant research program in CIM, the introduction of additional CIM-related courses, enhancement of CAD/CAM instruction, consulting services offered in CIM system design, and industry recruitment enthusiasm—all are by products of the CIM focus. In addition, UMR has taken a number steps to enhance university/industry collaboration in its CIM education program.

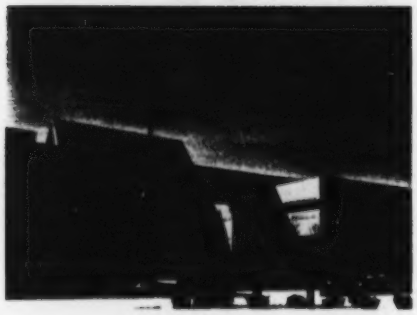
Evidence of that collaboration is DemMaTec (Demonstrating Manufacturing Technology), a non-profit corporation created by UMR to aid industry in adapting and implementing new manufacturing technologies. DemMaTec's first activity will be development of an 80,000 square-foot, state-of-the-art, metal-cutting facility to help small and medium-sized Missouri businesses produce discrete parts needed by the Department of Defense. A recent federal government directive stipulated that a certain percentage of such business must come from smaller firms.

With equipment installation planned for 1990 and full production slated for mid-1993, the off-campus DemMaTec facility will create nearly 100 jobs and draw on UMR expertise. Manufacturers across the state will "time share" the facility designed to produce approximately $10 million worth of parts per year.

Another use of UMR expertise is the Intelligent Systems Center (ISC), a state-funded effort to help transfer technology from campus to industry. With its services available to industry for an annual fee based on company size, the center works with UMR faculty and industry to identify specific needs. It then provides faculty members with resources to meet those challenges. A recent project for a corporate client involved the design of an automated system for manufacturing glass beads.

"Our investment in CIM and related areas is producing graduates with the skills needed to help make this country more competitive in manufacturing," comments Chancellor Martin Jischke. "Much of this effort is in partnership with industry. And projects like DemMaTec help us extend our reach to smaller and minority businesses." Adds Dean of Engineering Robert Davis, "In the future, we see more and more collaboration with business. We plan a strong extension program to help educate people in industry, including short courses developed from our CIM curriculum."

Pennsylvania College of Technology



CIM Emerges as a Primary Educational Focus at Penn College

Computer Integrated Manufacturing (CIM) has emerged as a primary educational focus at the Pennsylvania College of Technology (Penn College). This two-year institution, which was the Williamsport Area Community College prior to becoming a subsidiary of the Pennsylvania State University in 1989, offers 71 career-oriented programs. These provide hands-on education to more than 4,000 students from throughout, and beyond, the state.

Educators at Penn College say that demonstrating the entire CIM process to students and local businesses—from product design to warehousing—represents an educational thrust extending beyond the college's traditional charter. Instead of just providing basic occupational preparation for students in north central Pennsylvania, the CIM programs at the college represent innovative catalysts for change.

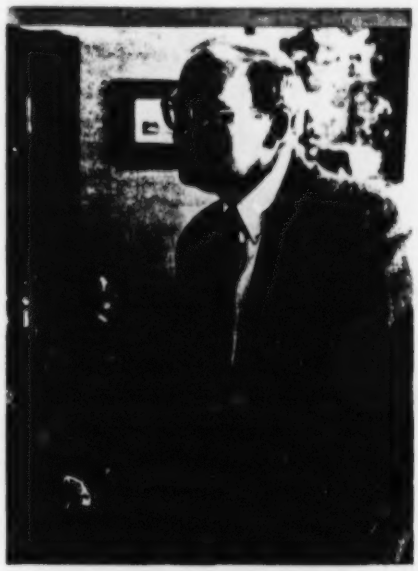
The success of the college's programs, which are helping transform local businesses into sophisticated, internationally competitive manufacturing operations, has attracted development grants from businesses and state and national government. Since 1983, the school has invested $40 million in a vigorous expansion of its campus facilities, including a new $25 million Advanced Technology and Health Sciences Center, which opened in fall 1987.

Robert Breuder, president of Penn College, considers community colleges vital educators on the cutting edge of technology transfer—especially in high-tech manufacturing. "You don't generate wealth if you don't produce anything," says Breuder. "The United States can't survive just as a service economy. If we don't aggressively pursue CIM, we will submerge in a global market."

As chief architect of the college's educational renaissance, Breuder is aiming to provide students with the CIM skills they will require to visibly impact local manufacturers. "The biggest single asset of the region is our graduates," comments Breuder. "Penn College is one of the first stops on the Chamber of Commerce's tour when prospective businesses visit the area."

Apparently, both businesses and students are getting Breuder's message. In its advanced technology programs, 100 percent of the college's CIM graduates are gaining immediate employment or moving into advanced degrees, while applications for and admissions to the program continue to rise quickly. Previously students were predominantly from the surrounding counties; now they come from every county in the state as well as from out-of-state.

"Students are more demanding in their expectations for deriving skills from a program," adds Breuder. "We witnessed a 14 percent increase in enrollments for the fall 1989 semester."



Robert Breuder, president of The Pennsylvania College of Technology, wants to provide CIM skills to students so they can participate in the growth of high-tech manufacturing in the region.

Pennsylvania College of Technology
PENNSTATE

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ɔounced Manufacturing Heritage
ddleton, dean of academic affairs, estrating fundamental change at ylvania College of Technology by ing the institution's focus from rs at the lower rungs of industry to a er perspective.

vent out and asked local manufac- where they wanted to be five years ɔow," says Middleton. "Many didn't and asked us for advice. In re- se, we developed a CIM curricula ure that involves students from uter science, business, and manu- ring, as well as those in drafting and ɪining."

College's response was to mobilize veral directions. According to Middle- t was necessary to approach CIM matically instead of piecemeal. eloping the facility, equipment, ware, and software into an integrated em was a major evolution. Middleton ends that they are about 95 percent e way there.

went with an IBM AS400 mainframe ɪputer and MAPICS (Manufacturing Production Inventory Control) ware as key components to integrate er than isolate CIM manufacturing shop-floor applications. It's a novel ɔroach few other schools have sued," comments Middleton.

ɔn College took the initiative to acquire nputers, software, equipment, space, d human resources as part of its plan, ddleton recalls. "From the start we ren't content to simply wait for things to ppen. And with $40 million of construc-

The academic team at Penn College includes (left to right): George Baker, director of industrial technology; Jim Middleton, dean of academic affiars; Donald Bergerstock, director of business and computer science; and George Wolfe, director of technology transfer.

tion college-wide and $16 million in equipment we physically transformed the institution."

The Advanced Technology and Health Sciences Center
In establishing CIM as an institutional priority, the most visible change on campus has been the construction of the Advanced Technology and Health Sciences Center—a 154,000-square-foot facility.

Close cooperation between faculty, Penn College administrators, and the center's architects resulted in a building designed to deliver advanced-technology programs efficiently. Four separate educational modules influenced building design: integrated communications, health sciences, computer science, and industrial technology.

This CIM laboratory is part of a $56-million investment by Penn College in computers, software, equipment, facilities, and human resources.

"The industrial technology module where students are trained, and the automated manufacturing lab where they gain experience, enabled us to leapfrog regional manufacturers", says George Baker, director of industrial technologies. "We tried to put all the CIM pieces together to build upon our substantial machine-tool base and to significantly expand our computing facilities. That enabled us to broaden the number of programs in which computers played an important role."

Students within the industrial technology module, for example, can focus on one of five advanced-technology electronics programs: automation instrumentation, biomedical electronics, computer automation maintenance, fiber-optic/communications, and laser electro-optics. Knowledge gained in these areas is immediately applicable to practical experience gained in the automated manufacturing laboratory, which consists of four manufacturing cells.

Industrial robots are the centerpieces of three manufacturing cells, which also include vertical milling machines and turning centers. A fourth cell remains dedicated to part inspection, fabrication, and assembly. A wire-guided-vehicle system transports parts from an "intelligent" warehouse to and between the cells. An IBM AS/400 mainframe for production scheduling—interfaced with 12 IBM PS/2s for CAD/CAM and four IBM industrial PCs for cell-level control—manages the operation of the entire automated manufacturing laboratory.

HESC—Paving the Transition to CIM

IBM instituted the Higher Education Software Consortium (HESC) in June 1988 to promote the use of computer technology in academic instruction and research. Any accredited, degree-granting institution of higher education may join the consortium. Its members gain access to broad-based groups of software with license fees waived and instead pay nominal annual fees.

"HESC participation is a very important asset that allowed us to accelerate our progress in CIM," says George Wolfe,

director of the technology transfer center. He acknowledges HESC played an important role in Penn College's emergence as a leader in high-tech manufacturing education. "It doesn't mean we are spending less, rather the consortium allows us to do more."

Participation in the consortium enabled Penn College, for example, to approach CIM without compromise and to experiment with software—an educational luxury Wolfe says they couldn't have justified beforehand. Software savings have permitted the school to expand its computing capabilities and develop its faculty, facility, and program resources.

"Buying software for CIM could easily run into six figures," says Wolfe. "Considering any particular CIM direction forced the school to examine the expenses involved. Working with restricted budgets, we would have had to compromise . . . and that would have jeopardized our systems approach."

During 1989, Penn College used consortium software from four groups: Selected AIX System Workstation Platform Programs, Selected Engineering/CIM Systems Workstation Programs, and Selected Business Application Programs.

"The HESC enabled us to invest wisely whereas we would have made bad decisions by 'nickel and diming' our purchases," adds Wolfe. "That would have rippled through our entire program which aims at demonstrating the entire manufacturing process."

Teaming with Industry and Government to be a Leader

Don Bergerstock, director of business and computing science, and other administrators at Penn College readily acknowledge that part of Penn College's tradition is teaming with local industry and working on community projects. That tradition has led the college to commit to curricula development that fosters collaboration among students on shared problems. Bergerstock is attracting business participation to challenge students with real business problems. Through the HESC, he is expanding curriculum offerings and integrating business and inventory control programs into the CIM environment.

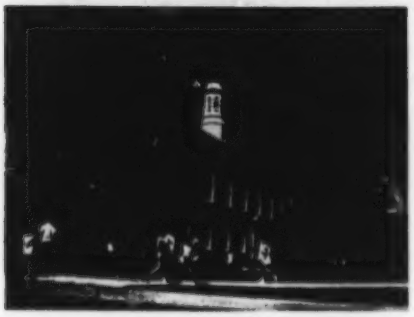
"We are setting up a unit to interface with industry for training, prototyping, and for testing out concepts on the shop floor to use our resources for research without involving their own capital," explains Bergerstock.

To accomplish that, Penn College creates a series of uncommitted positions while releasing faculty from full-time instructional responsibilities. The premise: small- and medium-sized businesses interested in repositioning themselves as competitive manufacturers through CIM will support these efforts.

Besides industrial partners, NSF assistance has helped PCT forge alliances with engineering research centers at Purdue, Carnegie-Mellon, Ohio State and Penn State. The objective is to investigate ways to link research with shop-floor activities. The Industrial Modernization Center, for example, growing from a Pennsylvania state-level economic development initiative and collaboration between Pennsylvania State University and Pennsylvania College of Technology, is using the university's research expertise in conjunction with Penn College's shop-floor expertise to develop programs for business and industry.

"Our ultimate goal is to bring universities, vendors, user companies, and community colleges together as training sites to shape research and make it pragmatic," says Bergerstock. "Too much research ends up on the shelf. We want to use what is already proven, develop new concepts, and accelerate the application of CIM to increase industrial competitiveness."

University of Southwestern Louisiana



Partnerships with Industry Foster Strong CIM Initiative

Rougeou Hall dramatizes the University of Southwestern Louisiana's (USL) commitment to CIM—and its unique partnerships with industry. The new industrial technology building houses a $5.3-million "Factory of the Future," CAD workstation labs, and a variety of other facilities dedicated to CIM-based training, design, and production. Much of the CIM-related hardware and software has been donated by industry.

Also located in the 90,000-square-foot building is the Louisiana Productivity Center—a state-supported focal point for the revitalization of Louisiana industry. Through technical innovation, procurement assistance, and use of USL CIM training/research facilities, the Productivity Center helps Louisiana industry develop, manufacture, and market more competitive products. And in further partnership with industry, USL is soon to be the site of nation's first CIM center for the apparel industry, a joint venture with the American Apparel Manufacturers Association.

CIM: A New Partnership with Industry

Second largest university in the state, the University of Southwestern Louisiana (USL) has long been known for its development of solid industry/university relationships. In the 1980's, USL forged a new partnership that has resulted in a state-of-the-art CIM facility and manufacturing technology aid to over 70 Louisiana industries a year. The CIM initiative is centered in Rougeou Hall, a new $7 million facility dedicated to CAD/CAM training for USL students and Louisiana industry executives.

USL's CIM program owes some of its origins to shifting demand in the oil industry. A decade ago, the Interstate 10-New Orleans-Houston corridor represented one of the nation's largest concentrations of metalworking shops. By 1982, however, demand for oilfield metal products had slackened. Metalworking businesses closed up or cut back dramatically. Many had already purchased costly computer-numerically-controlled (CNC) equipment they barely knew how to use. USL was approached for help.

"We took it on ourselves to help change an oil-based economy to a manufacturing economy," notes USL President Ray Authement. "Louisiana companies needed to find new products to manufacture. Leadership in computer science and engineering made USL a logical choice for development of CIM expertise."

"USL set out to develop a fully functional 'Factory of the Future,' " recalls John Stephens, professor of mechanical engineering and the driving force behind USL's CIM effort. "To do this we needed corporate sponsors. Our approach, however, was to develop close working relationships. We sought a partnership with industry, not a handout."

The approach worked. Cincinnati Milacron, Structural Dynamics Research Corporation, Kennametal, and others contributed equipment, software, and training for a CIM lab. In return, corporate

Ray Authement, president of the University of Southwestern Louisiana, believes the university can broaden the oil-dependent regional economy into the manufacture of other products.

sponsors were to use the USL facilities for product feasibility and demonstrations of flexible manufacturing. Before long, USL was able to automate the design and production of scores of products—at no charge or obligation to corporate sponsors. The groundwork was laid for a broad CIM initiative.

At the same time, USL used its newly-developed CIM lab to train engineering students—and developed a degree option in CAD/CAM within the mechanical engineering curriculum. Using computer terminals, students could design a part, subject it to software-simulated tests, and create instructions for USL's Cincinnati Milacron unmanned work cell—a series of CNC-controlled lathes and milling machines each loaded and unloaded by its own robot.

Birth of the Louisiana Productivity Center

By 1985, the need for diversification of the state's economy—and CIM expertise—had intensified. Metalworking shops, shipyards and drilling barge fabrication yards continued to close. Louisiana industry needed direct assistance. USL proposed a cooperative extension service for manufacturers. State legislators were shown how USL could put its CAD/CAM leadership directly to work for industry.

In 1986 the state legislature responded with a grant of $1 million to establish the Louisiana Productivity Center, which is actually three centers in one. Each functions like a spoke in a wheel. The Technical Innovation Center provides industrial and product incubation—aiding inventors in patent research, product design, prototype development, and product testing. The Federal Procurement Center helps client companies in bidding on federal contracts. The Productivity Center itself helps client companies reduce product development time, improve product quality, increase manufacturing efficiency, and increase profit margins—all with CIM technology.

To provide this no-cost consulting to some 70 companies a year, some winnowing is necessary. Companies are judged on six criteria: attitude, economic impact, manufacturing capabilities, financial capability, location, and potential for a secondary line of products. Productivity Center personnel visit a prospective client, interview company officers, and tour the physical plant. "The key determinant is the creation of jobs," comments John Stephens. "The center has helped five-person companies with a small CAD setup and one or two CNC machines as well as much larger firms able to invest heavily in capital equipment."

The Productivity Center staff is made up of project engineers, federal procurement specialists, automated manufacturing engineers, CAD specialists, training personnel, and consultants. USL faculty are consulted for their expertise. "Centers that start with primarily faculty people have usually failed," reflects Stephens.

By all measures, the Productivity Center is a success. Clients range from Pierre Part Seafood to Morton Thiokol. Staff

John Stephens, professor of mechanical engineering and driving force behind USL's CIM effort, sought a partnership with industry, not a handout.

professionals maintain one-to-one communication with 135 companies in the state, and disburse information to over 2,100. Some 200 product ideas have been examined, with 25 under development and ten already on the market. In a recent 9-month period, direct Productivity Center intervention yielded $48 million in contracts for Louisiana client companies, with engineering assistance provided for another $110 million.

Says Steve Killingsworth, director of the Productivity Center, "Inventors with ideas such as the Trigger Hitch—a multi-purpose towing hitch for use with RV's—are typically forced to spend thousands of dollars for an evaluation of their ideas.

"USL set out to develop a fully functional 'Factory of the Future.' To do this we needed corporate sponsors. Our approach, however, was to develop close working relationships. We sought a partnership with industry, not a handout."

JOHN STEPHENS, PROFESSOR OF MECHANICAL ENGINEERING

They tend to leave those ideas in the desk drawer. The Productivity Center helps prevent that from happening in Louisiana. Sometimes the solution is simple—introducing Mr. A to Mr. B."

"Our opinion and efforts have really mattered," adds John Stephens. "Morton Thiokol in Shreveport wanted to totally automate one of the largest munitions factories in the U.S. We came up with a new concept in tooling and invited them down to see production on our unmanned work cell. We showed them how 155-mm howitzer shell casings could be produced 26 percent faster. They could time the process to within a tenth of a second. As a result of our demonstrations, they ordered 17 'copies' of the unmanned cell for themselves—and won a $400-million contract. Over 800 people were put back to work."

State-of-the-art CIM Facilities

While the Louisiana Productivity Center provides ideas and information, USL's Rougeou Hall is home for the hardware, software, and other resources supporting the CIM initiative. Its three floors house the CIM Center and labs for just about any CIM-related activity—including CAD/CAM, robotics, computer-aided drafting, testing, thermofluids, and basic computer training. One full floor is dedicated to classrooms.

Recently, IBM added its sponsorship to the USL CIM program, providing a range of hardware and software for use in Rougeou Hall and supporting the establishment of USL as an Executive CIM Training Center. The newly donated equipment is linked to the school's IBM 3090™-200 mainframe processor in the nearby Stephens Hall computing center.

Resources supporting CIM activities are concentrated in Rougeou Hall, where students use sophisticated equipment to plan, set up, and manage manufacturing operations.

Students, executives, and Productivity Center staff can now design, draft, test, and produce a part in a fully functional CIM environment. The process starts with computer-aided design, the creation of a solid model or proposed design solution. Most of this work is done in the CAD Workstations Lab—a room with 14 IBM RT Systems and three 5080 Graphics Stations linked to the IBM 3090 mainframe. Using CAEDS software, the terminals are linked on an IBM Token-Ring Network and operate under the IBM AIX™ operating system.

In the same environment, users can perform finite-element analysis, dynamic

testing, and computer-aided drafting. The three-dimensional solid model can be used to extract a full-dimensioned engineering drawing. This geometry is then used to create appropriate CNC machinery commands. At this point, the process calls for CIM-cell programming. Using network software and IBM PS/2 computers, a master CIM control system is created for production in USL's CIM Center.

The CIM Center includes an automated storage/retrieval system, two vertical machining centers, one turning center, a flexible conveyor, three pallet load/unload positions, and two robotic devices. The entire process is under control of an IBM PS/2 Model 70 computer.

Mohamad Samadi, mechanical engineering computer system manager, instructs students and executives in this classroom equipped with IBM RT Systems.

CAD/CAM Option and Executive CIM Training Seminar

USL's CIM facilities are in almost constant use. All mechanical engineering students, for example, take courses in computer concepts, solid modeling, and computer drafting in their freshman year. Hands-on training with IBM RT Systems and 5080s is emphasized. By sophomore year, they can elect a CAD/CAM option—with a variety of advanced courses in computer-aided design and drafting. CAM is taught in the senior year, with extensive use of the CIM Center.

In addition, USL teaches the entire process in several executive CIM training seminars a year. Attendees are high-level corporate executives directly responsible for approving and implementing CIM technology. In two days, up to 35 executives per class design, test, draft, and manufacture their own "candy can" product, gaining a working knowledge of essential CIM elements. Dedicated instructors and a thick workbook guide them through the experience.

"We are expanding our CIM effort ," comments Mohamad Samadi, mechanical engineering computer system manager and an executive seminar instructor, "On one level, that means tighter integration between CAD and CAM, including the ability to communicate NC code directly to the machines. On another, it means integration with MIS. We are installing IBM MAPICS II software on an IBM AS/400 system with 10 terminals, to integrate CIM data all the way from order entry, capacity requirements planning, and inventory management through production planning, shop floor control, shipping, invoicing, and accounting applications."

Site of First CIM Facility for the Apparel Industry

USL's CIM initiative has produced yet another partnership. In a joint effort with the American Apparel Manufacturers Association (AAMA), USL will be the site of the first A-CIM center. Funding of $2.5 million over three years—including AAMA, USL, and Louisiana legislature contributions—will support research and development for the apparel industry.

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